

**Mixing and Hydrogeologic Influences on the
Chemical Composition of the Olentangy
River, Ohio**

**Presented in partial fulfillment of the requirements for the
Bachelor of Science degree in the Geology Department of The
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by

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Abstract

Water samples collected from the Olentangy River in August, 1995, have been sent for analysis by ICP (X-Ray Assay Labs. Toronto, Ontario, Canada) and tested for the concentrations of Be, Na, Mg, Ca, Cu, Zn, Ba, K, P, Fe, Mn, Sc, Ti, V, Cr, Co, Ni, As, Sr, Y, Zr, Mo, Ag, Cd, Sn, Sb, La, W, Pb, Bi, and Al. Trends and patterns searched for in the data produced a decrease in the concentrations of Na, Mg, Ca, Cu, Zn, and Ba due to dilution, and erratic behavior in P, Fe, Mn, Sr, and Al which allowed no conclusions to be drawn from the data for these elements. The concentrations of the rest of the elements were below their sensitivity limits. At the confluence of the Olentangy and Scioto Rivers, the concentrations of Na, Mg, Ca, Cu, Zn, and Ba increased due to mixing. Irregular behaviors were discovered in the plots of sodium vs calcium and sodium vs magnesium downstream in the Olentangy River, Ohio. The reason behind this is basis for another study.

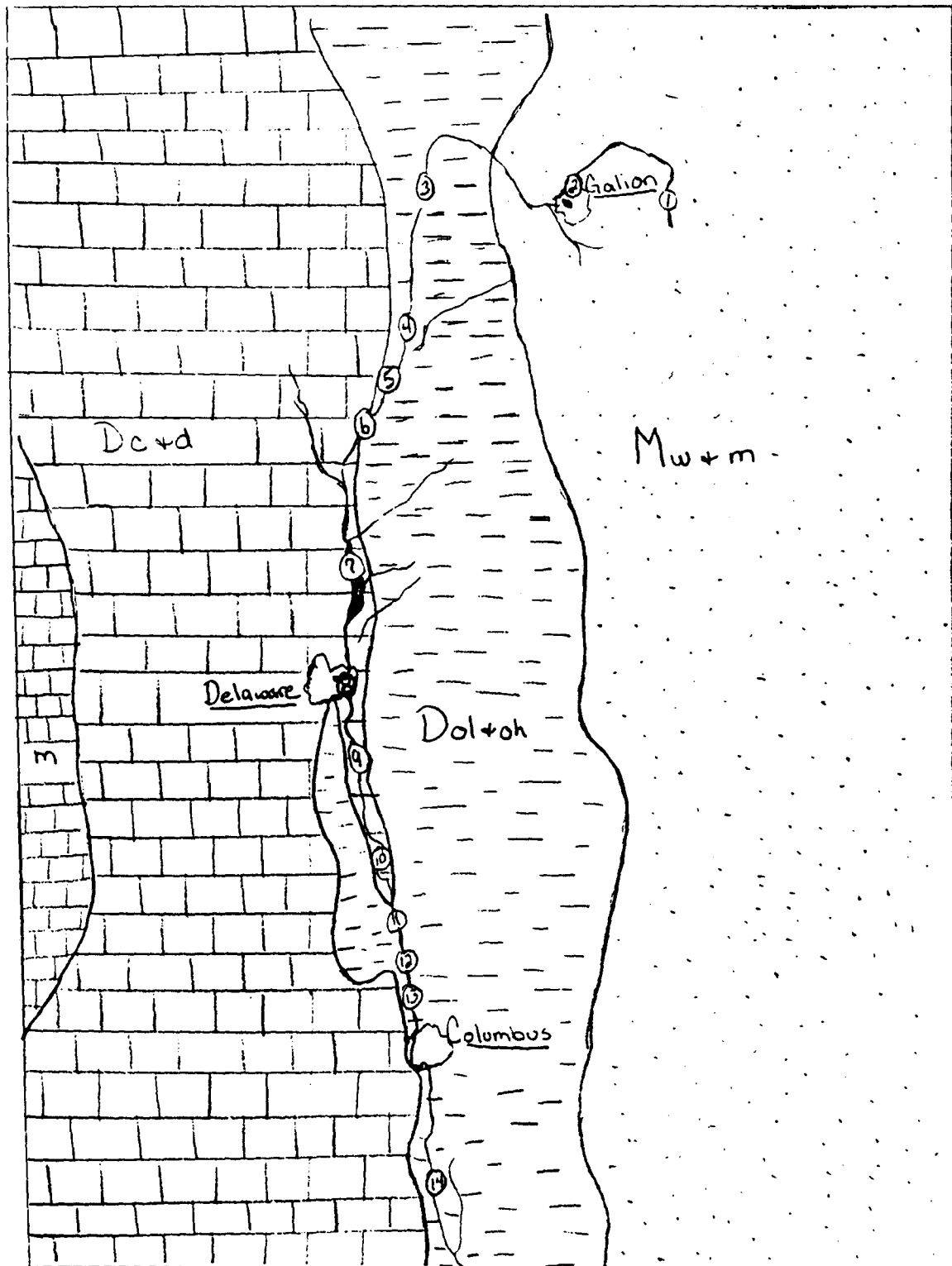
I. Introduction

The Olentangy River is a typical river in central Ohio having a north-south trend through Morrow, Crawford, Marion, Delaware and Franklin Counties, where it then empties into the Scioto River. The land over which the river flows is composed of Devonian sedimentary rocks covered by Wisconsinian till and outwash deposits. It cuts through Wisconsin moraines and local alluvium to expose these Devonian rocks including (from the north to the south) the Columbus Limestone, the Delaware Limestone, the Olentangy Shale and the Ohio Shale (See Map 1). The Olentangy River flows through several cities including Galion, Claridon, Delaware, and Columbus, Ohio.

The water composing the Olentangy River is a mixture of rainwater, groundwater, and surface runoff from the surrounding area. In fact, the chemical composition of this water is directly related to the mineralogy of the underlying and surrounding rock units. The presence of humans, however, can influence this composition. Discharge of municipal or industrial wastes and use of fertilizers and pesticides can alter the chemical composition of streams. The concentrations of the major chemical elements can be determined by chemical analysis. However, the concentrations of some elements are below the limits of detection. The present study includes the entire Olentangy River from the beginning in the north to past the southern end where it joins the Scioto River, south of Columbus. Previous

studies concerning chemical compositions of the Scioto and Olentangy Rivers include the work of Hicks (1994), and Eastin and Faure, 1970.

The effects of hydrogeological processes on the chemical composition of the river are expected to be revealed as the result of this study, and the issues addressed include 1) the presence of any trends in concentrations of major elements composing the Olentangy River, 2) changes in the compositions below the confluence of the Scioto and the Olentangy Rivers. In particular, I expect that the concentrations of sodium and calcium will increase downstream because these elements occur in sewage effluent released into the Olentangy River in Ohio.



Map 1: Map showing locations of samples along the Olentangy River, Ohio.

II. Sample Collection

Polyethylene bottles (500 mL) were used to collect fourteen samples of the Olentangy River water. The bottles were cleaned using dilute nitric acid and then rinsed with distilled water. The samples were collected on August 13, 1995, in the hours before noon. The weather was cool and slightly overcast until about 10:00 a.m.. Samples 1 through 7 were collected by Gunter Faure and I collected the rest.

The water was collected from bridges over the river. Each bottle was first rinsed with the water before it was filled with the sample. Bottles were filled completely to the top and the lid was placed on carefully so as not to leave any air in the bottle which were then stored in a cool dry place for later analysis.

The fourteen samples were collected at the following locations (see also Map 1):

H-95-1: Near the source of the river, east of Galion, off route 97 where the river resembles a ditch.

H-95-2: In the city of Galion at the bridge on route 19 (approx. 6.3 km from sample 1).

H-95-3: Bridge on route 100 over the river (approx. 12.4 km

from sample 2).

H-95-4: North of Caledonia on route 309 bridge (approx. 12.4 km from sample 3).

H-95-5: At the city of Claridon, bridge on route 95 (approx. 7 km from sample 4).

H-95-6: Bridge on route 529 (approx. 4.5 km from sample 5).

H-95-7: South of the city of Waldo and north of Delaware Lake bridge on route 229 (approx. 13.25 km from sample 6).

H-95-8: Southern end of Delaware city, off routes 36 and 37 (approx. 16.25 km from sample 7).

H-95-9: Just south of the city of Stratford off route 23 (approx. 4.5 km from sample 8).

H-95-10: Bridge on Powell Rd. (approx. 13.25 km from sample 9).

H-95-11: In Worthington off route 161 (approx. 5.75 km south of sample 10).

H-95-12: Bridge on Woody Hayes Drive on The Ohio State University campus (approx. 5.25 km south of sample 11).

H-95-13: Bridge on Fifth Ave. in Columbus (approx. 6 km south of sample 12).

H-95-14: Bridge on route 665 in Shadeville south of Columbus (approx. 20.25 km south of sample 13).

III. Sample Preparation

The samples were filtered using 0.45 μ m Millipore filters. About 125 mL of each sample was used to rinse the apparatus before it was used to filter the water. Each filtered sample was acidified using 1 mL 15N nitric acid. The filtered and acidified samples were allowed to stand overnight at room temperature. Then, a 30 mL aliquot of each sample was sent for analysis by ICP (X-Ray Assay Labs. Toronto, Ontario, Canada). Sample H-95-14 was made in triplicate in order to examine the precision of the analyses. The two extra samples are H-95-15 and H-95-16.

IV. Presentation of Results

The detectable elements and their concentrations are indicated on Table 1. Most of the detectable elements have been plotted on Figures 1 through 8. (Graphs for manganese, aluminum, and phosphorus are not included.) Several of the elements displayed similar behavior, these were sodium, magnesium, calcium, copper, zinc and barium, all which have decreasing concentrations downstream. Others such as iron, manganese, strontium, aluminum, and phosphorus were erratic in their behavior. Potassium shows a decreasing trend in concentration for about 40 kilometers. Between this point and the next where samples were taken, at approximately 60 km, there is a sharp increase in the concentration followed by a gradual decrease. The location of this anomaly is just north of the Delaware Lake Reservoir.

The ranges in the concentration of the elements are as follows:

| Elements | Lowest Concentration (ppm) | Highest Concentration (ppm) |
|----------|-------------------------------|--------------------------------|
| Sr | .184 | .528 |
| Na | 4.44 | 29.2 |
| Mg | 7.83 | 22.2 |
| Ca | 30.6 | 86.7 |
| Cu | .005 | .099 |
| Zn | .009 | .159 |
| Sr | .184 | .711 |
| Ba | .29 | .57 |
| Al | .049 | .243 |
| P | .049 | .135 |
| K | 3.97 | 4.97 |
| Mn | .012 | .039 |
| Fe | .105 | .384 |

TABLE 1: Table showing concentrations of detectable elements in the Olentangy River.
Refer to text for geographic locations.

| | | Element Concentration (ppm) | | | | | | | | | | | | |
|---------|------------|-----------------------------|------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|--|
| Sample | Dist. (km) | Na | Mg | Al | P | K | Ca | Mn | Fe | Cu | Zn | Sr | Ba | |
| H-95-1 | 0.5 | 29.2 | 19.7 | 0.049 | 0.105 | 4.4 | 66.6 | 0.021 | 0.105 | 0.099 | 0.159 | 0.184 | 0.045 | |
| H-95-2 | 6.3 | 21.8 | 22.2 | 0.165 | 0.049 | 4.46 | 86.7 | 0.013 | 0.228 | 0.038 | 0.064 | 0.528 | 0.057 | |
| H-95-3 | 18.6 | 16.5 | 18.6 | 0.049 | 0.066 | 4.29 | 71.7 | 0.013 | 0.134 | 0.02 | 0.023 | 0.377 | 0.046 | |
| H-95-4 | 31 | 9.6 | 15.9 | 0.093 | 0.049 | 4.06 | 62.2 | 0.025 | 0.323 | 0.022 | 0.025 | 0.711 | 0.042 | |
| H-95-5 | 38 | 8 | 15.6 | 0.134 | 0.049 | 3.97 | 59.9 | 0.03 | 0.384 | 0.02 | 0.016 | 0.542 | 0.049 | |
| H-95-6 | 42.5 | 7.8 | 15.3 | 0.13 | 0.049 | 3.99 | 58.5 | 0.039 | 0.294 | 0.019 | 0.01 | 0.513 | 0.047 | |
| H-95-7 | 56 | 5.7 | 9.16 | 0.185 | 0.093 | 4.97 | 33.2 | 0.016 | 0.279 | 0.018 | 0.013 | 0.242 | 0.032 | |
| H-95-8 | 72 | 4.47 | 7.79 | 0.101 | 0.07 | 4.76 | 30.6 | 0.021 | 0.141 | 0.011 | 0.034 | 0.209 | 0.03 | |
| H-95-9 | 76 | 4.44 | 7.85 | 0.111 | 0.049 | 4.69 | 33.1 | 0.017 | 0.192 | 0.011 | 0.028 | 0.246 | 0.031 | |
| H-95-10 | 89.5 | 4.45 | 7.83 | 0.156 | 0.103 | 4.84 | 31.4 | 0.022 | 0.156 | 0.012 | 0.016 | 0.23 | 0.031 | |
| H-95-11 | 95 | 4.72 | 7.87 | 0.243 | 0.073 | 4.7 | 31.4 | 0.012 | 0.265 | 0.007 | 0.009 | 0.22 | 0.03 | |
| H-95-12 | 100.6 | 11.9 | 12.6 | 0.171 | 0.049 | 4.82 | 46.2 | 0.032 | 0.261 | 0.006 | 0.02 | 0.338 | 0.037 | |
| H-95-13 | 107 | 4.86 | 7.84 | 0.08 | 0.135 | 4.65 | 30.8 | 0.013 | 0.116 | 0.005 | 0.009 | 0.217 | 0.029 | |
| H-95-14 | 127 | 7.59 | 9.92 | 0.072 | 0.109 | 4.83 | 36.7 | 0.034 | 0.196 | 0.013 | 0.009 | 0.384 | 0.031 | |
| H-95-15 | duplicate | 7.58 | 9.96 | 0.101 | 0.114 | 4.87 | 36.8 | 0.035 | 0.21 | 0.013 | 0.008 | 0.384 | 0.031 | |
| H-95-16 | duplicate | 7.55 | 9.91 | 0.128 | 0.11 | 4.88 | 36.6 | 0.034 | 0.239 | 0.011 | 0.008 | 0.381 | 0.031 | |

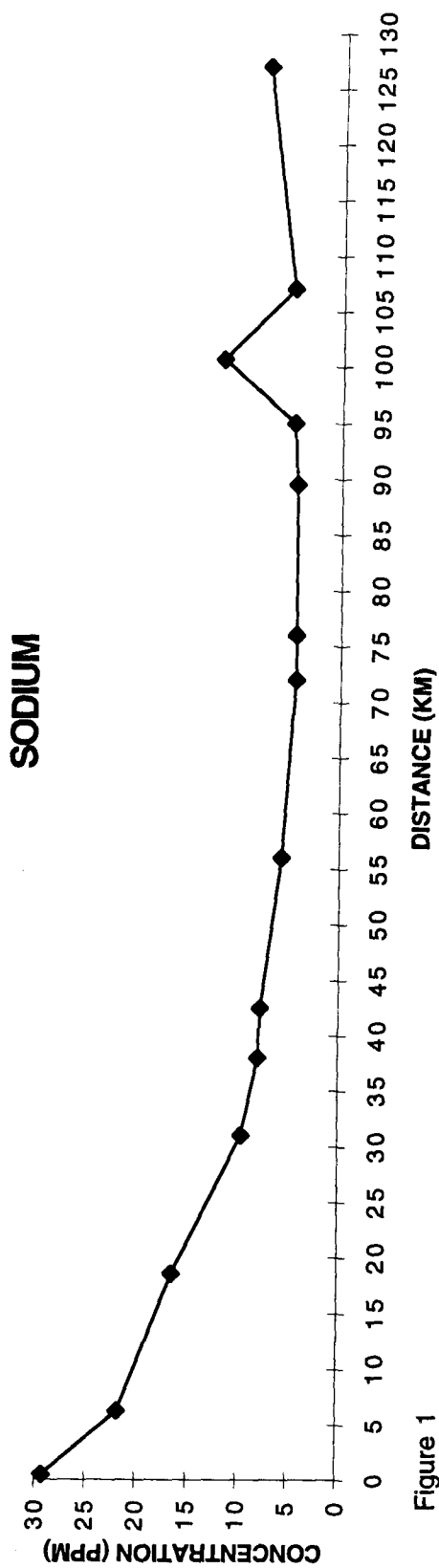


Figure 1

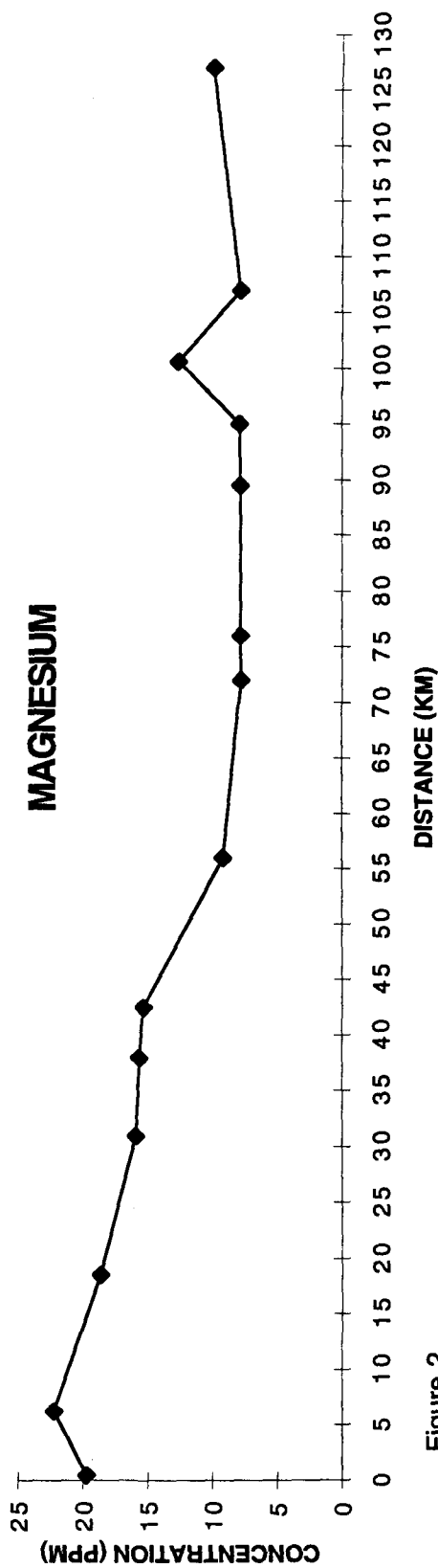


Figure 2

Figure 1 and Figure 2: Show decrease in sodium and magnesium concentrations downstream in the Olentangy River, Ohio.

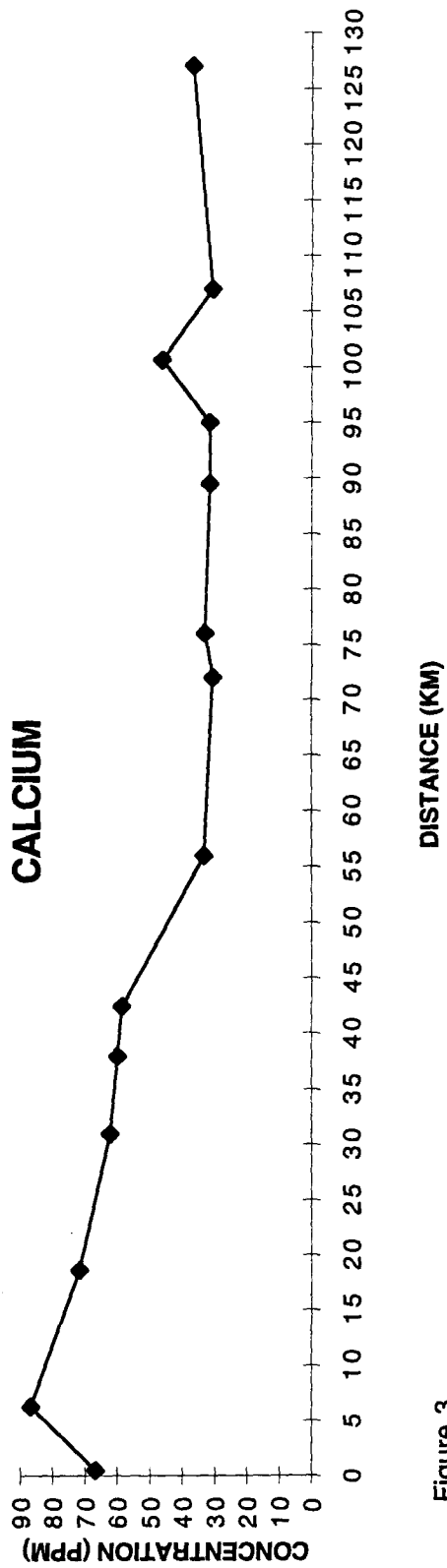


Figure 3

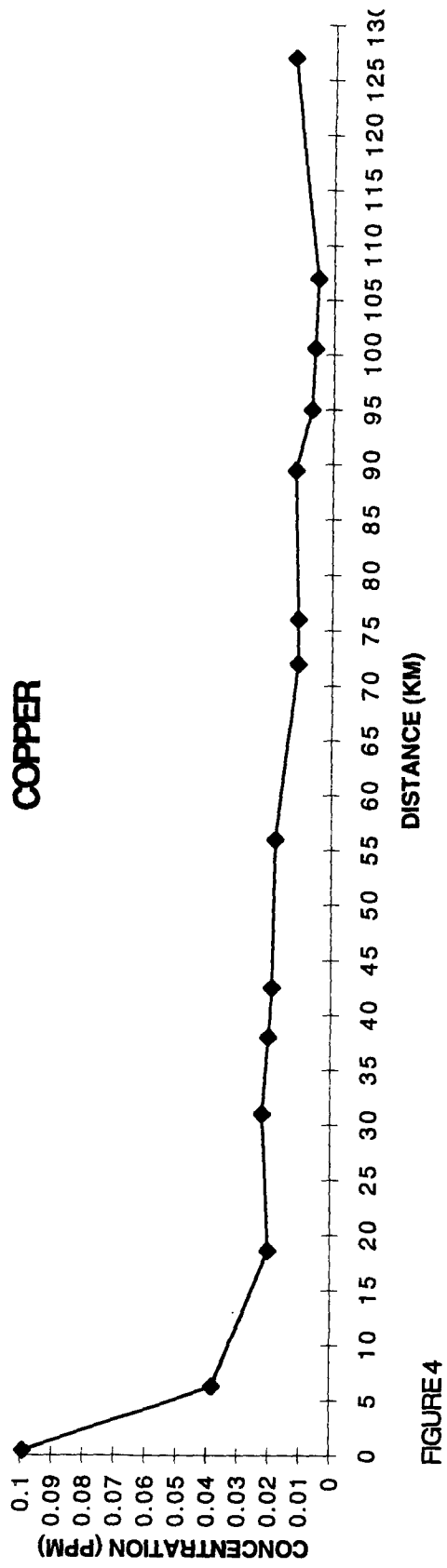
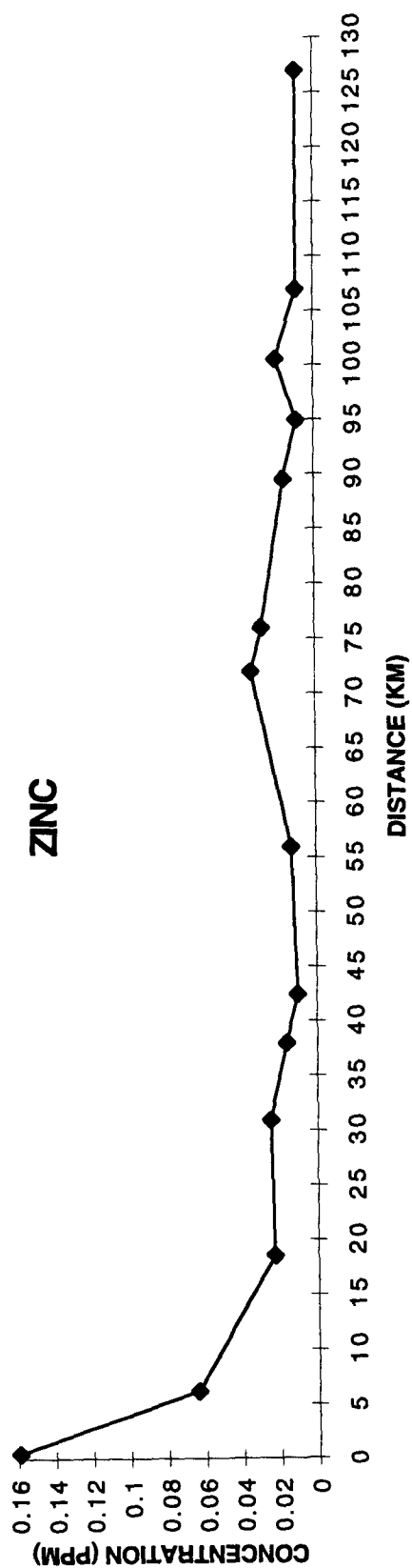


Figure 3 and Figure 4: Show a decrease in calcium and copper concentrations downstream in the Olentangy River, Ohio.



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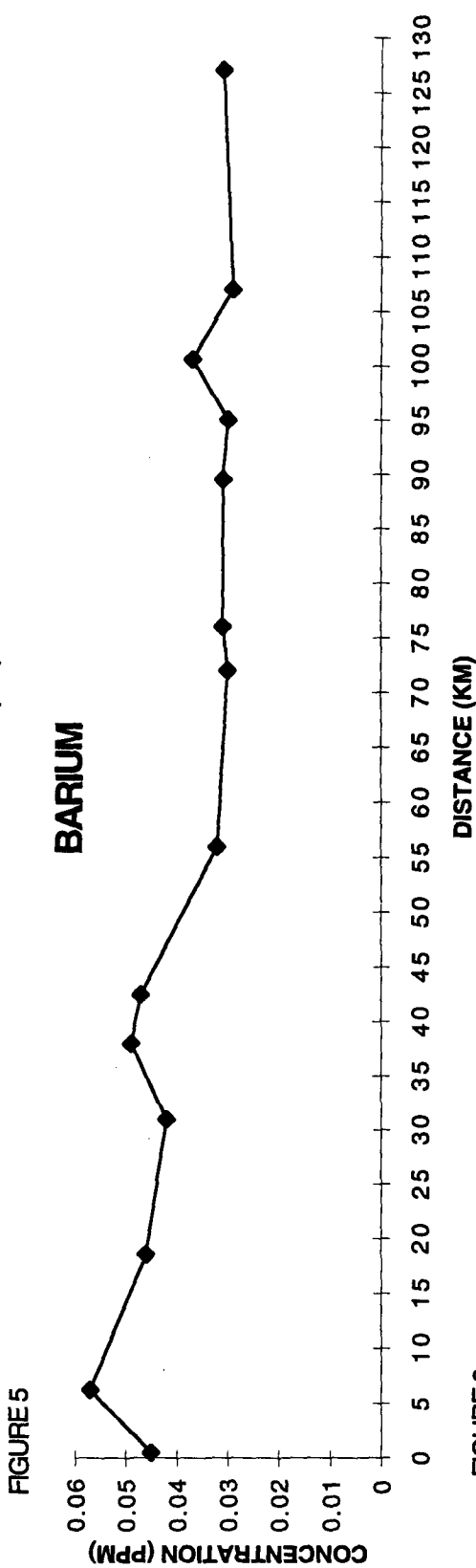


Figure 5 and Figure 6: Show a decrease in zinc and barium concentrations downstream in the Olentangy River, Ohio.

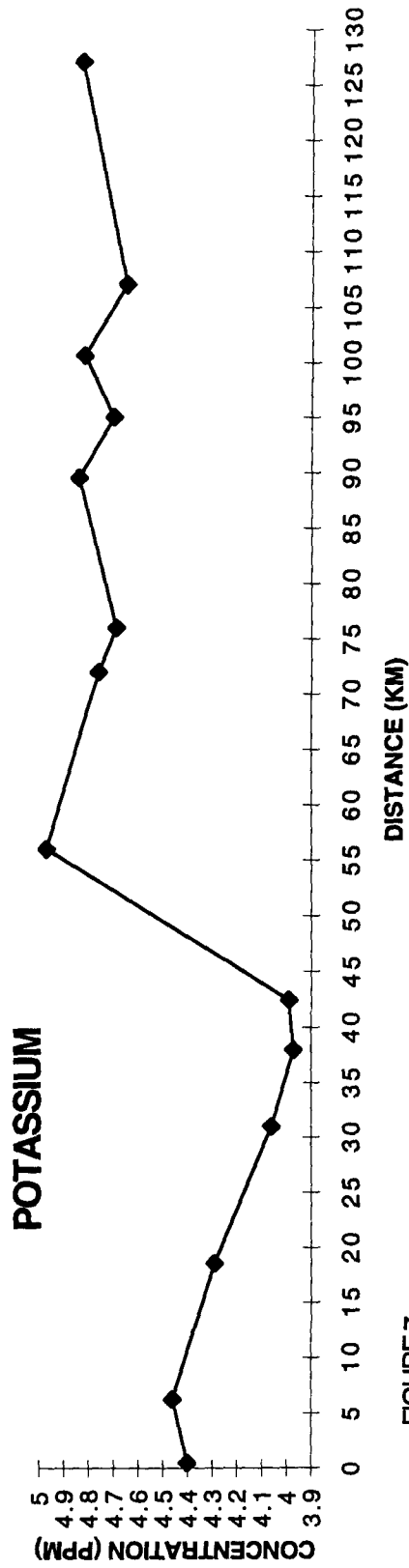


FIGURE 7

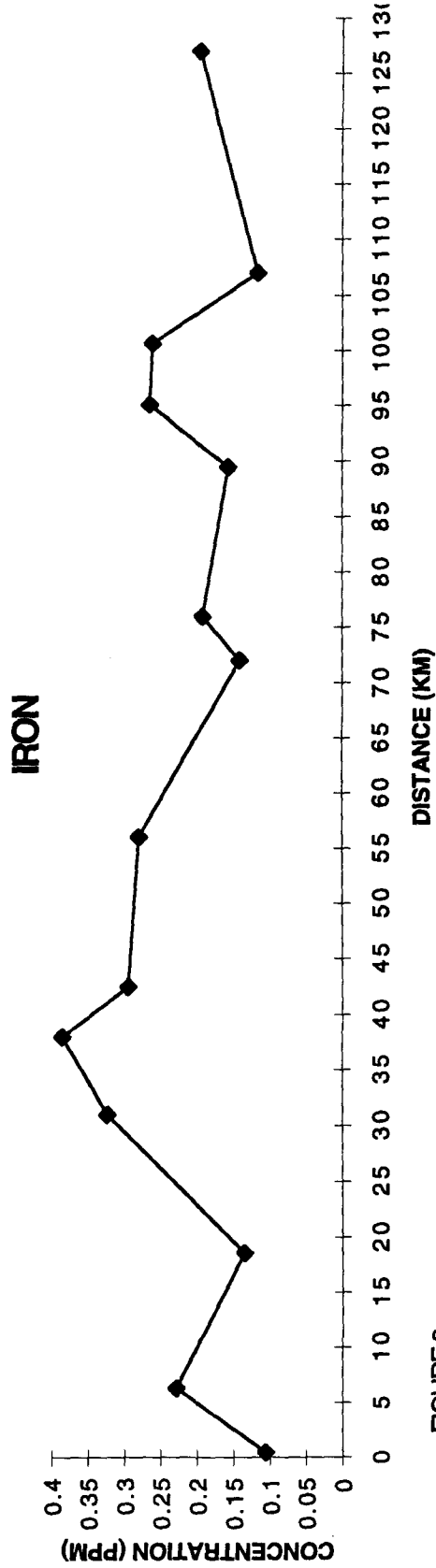


FIGURE 8

Figure 7 and Figure 8: Show unusual behavior of potassium and erratic behavior of iron in the Olentangy River, Ohio.

V. Discussion

The graphs reveal a gradual decrease in the concentrations of Na, Mg, Zn, Ba, Ca, and Cu. A possible explanation for this is an increase in the discharge of water downstream with little addition of these elements (illustrated in figure 9). The increase of the discharge is indicated by data at Claridon, Ohio, (near location of sample H-95-5) which recorded a discharge of 206 cubic feet/second, whereas at, Delaware (near location of sample H-95-8) the discharge was 4430 cubic feet/second¹ on August 13, 1995.

Graphs comparing concentrations of calcium and sodium, and magnesium and sodium downstream reveal linear trends in the concentrations of these elements trends (See Figures 10 and 11). All the points on the upper line in each graph are from the area above the Delaware Reservoir, and all the points on the lower lines, except for two, are from the area below the Delaware Reservoir. The reason for this behavior may be related to the underlying bedrock, but to be certain, another study must be conducted.

The concentrations of Ba, Ca, Zn, K, Al, Fe, Mn, Na, and Mg show a small irregular peak at the location of the French Field House on the Ohio State University campus. Upon investigation, a pipe emptying surface runoff into the Olentangy River was discovered on

¹ Provisional data for August 13, 1995, subject to revision (United States Geological Survey, Columbus, Ohio)

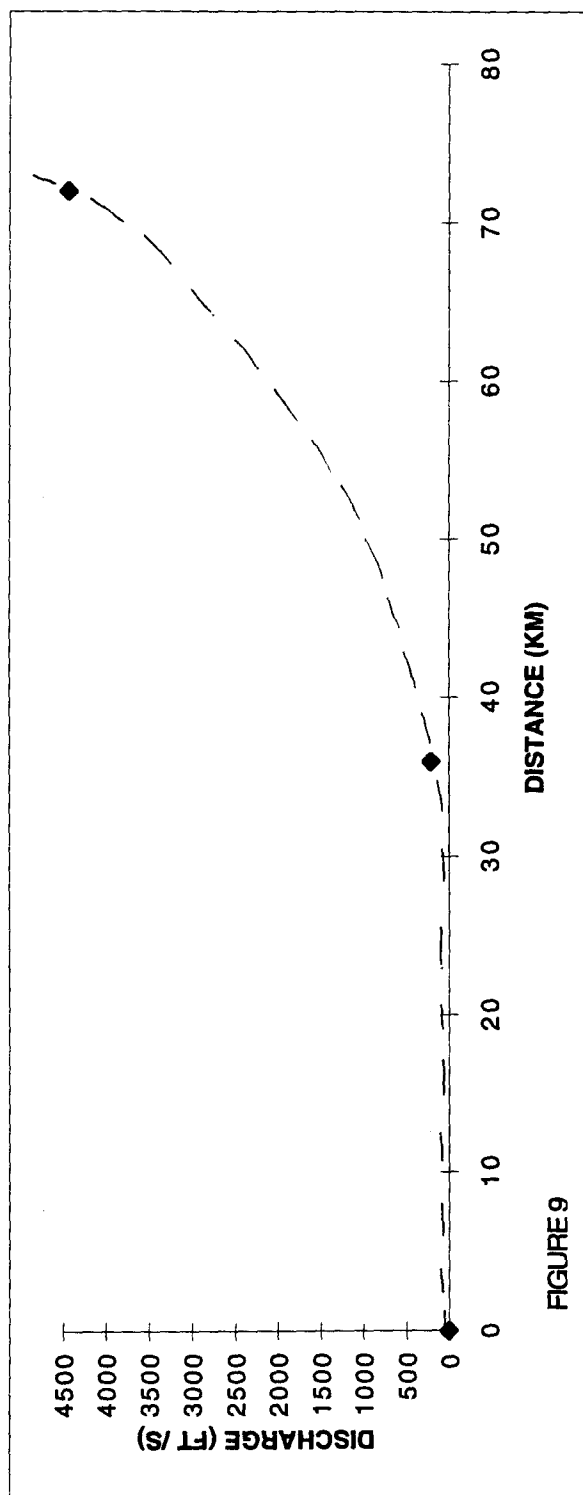


FIGURE 9: Shows increase in discharge downstream. Data provided by the United States Geological Survey, Columbus, Ohio.

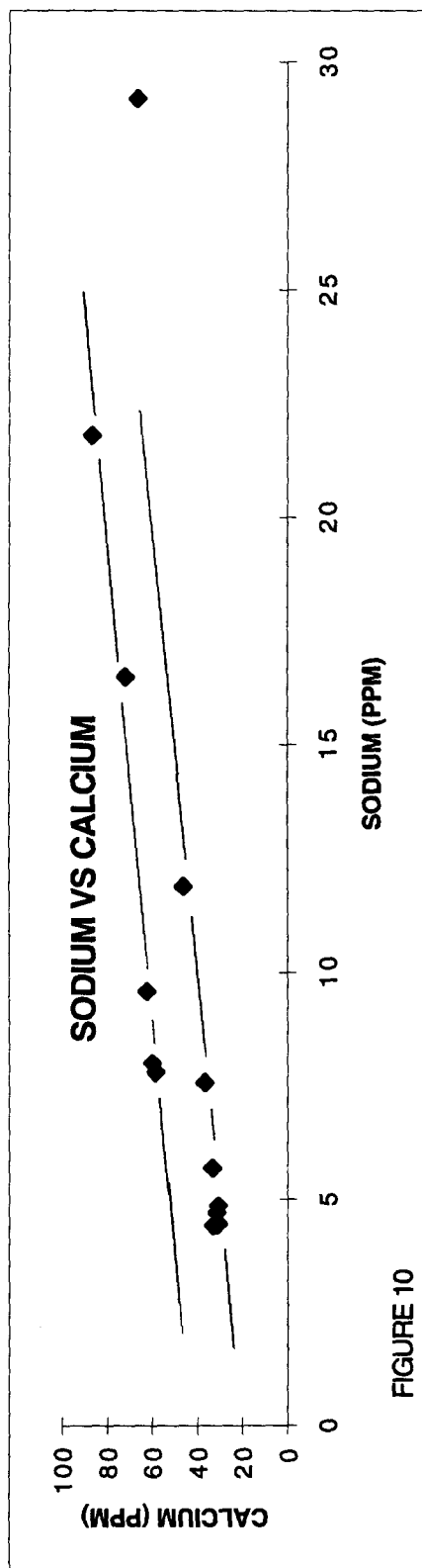
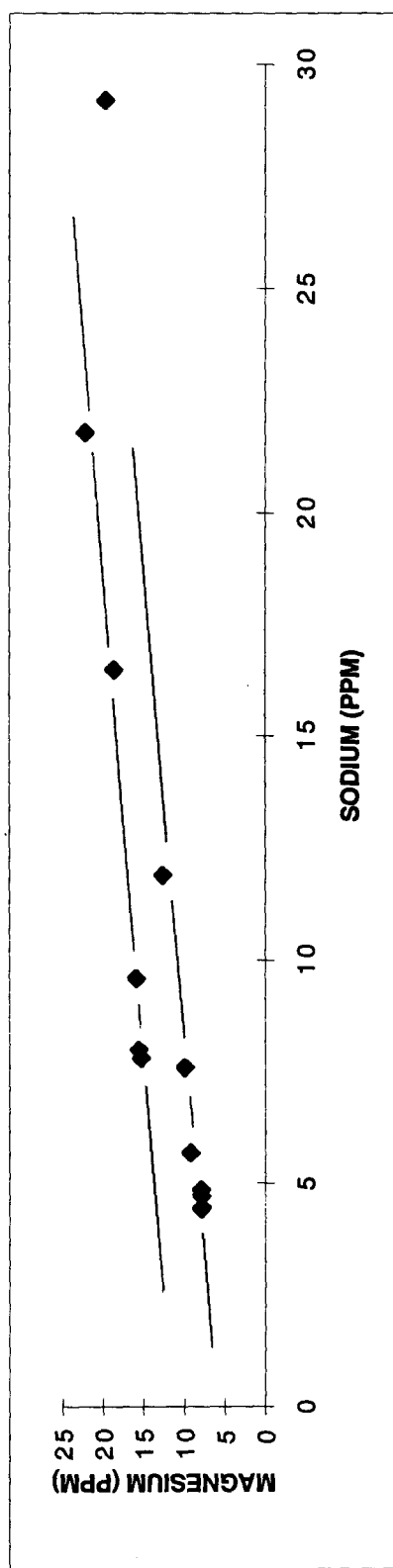


FIGURE 10



Figures 10 and 11: Show the relationship between sodium and calcium and sodium and magnesium downstream in the Olentangy River, Ohio.

the north side of the bridge on Woody Hayes Drive. This is a probable explanation for these peaks. The data suggest that the water being dumped into the river has elevated concentrations of these elements.

The concentrations of Mn, Fe, Al, Sr, and P display erratic behavior and no trends can be observed from the data. Manganese, iron, and aluminum form oxides or hydroxides that are very sensitive to the pH of the water. Therefore, a small change in the pH of the water may affect their concentrations. Phosphorus is found in fertilizers and sewage in large amounts. Its concentration would therefore be affected by the amount of runoff from farms or other cultivated areas, and the discharge of municipal or industrial waste water being emptied into the river.

At the location of the Olentangy-Scioto confluence, there appears to be an increase in the concentrations Na, Mg, K, Ca and Cu. This may be due to mixing of the waters of the Olentangy and the Scioto. The data of Hicks (1994), indicate that the concentrations of both Na and Mg in the Scioto river above the confluence are higher than they are below the confluence. The mixing of water of the Scioto River with the Olentangy causes the concentrations of these elements to be lower below the confluence than they are in the Scioto River above the confluence. Calcium concentrations, however, increase continuously even with the addition of the Olentangy to the Scioto River. Plots of calcium and sodium concentrations above and below

the confluence reveal that at the location of Shadeville, Ohio, the river contains mostly Olentangy River water (See Figure 12). To determine how much, the line distance between B and As is divided by the distance between Ao and As and multiplied by 100%. I discovered that at Shadeville, the water is approximately 84% Olentangy River water.

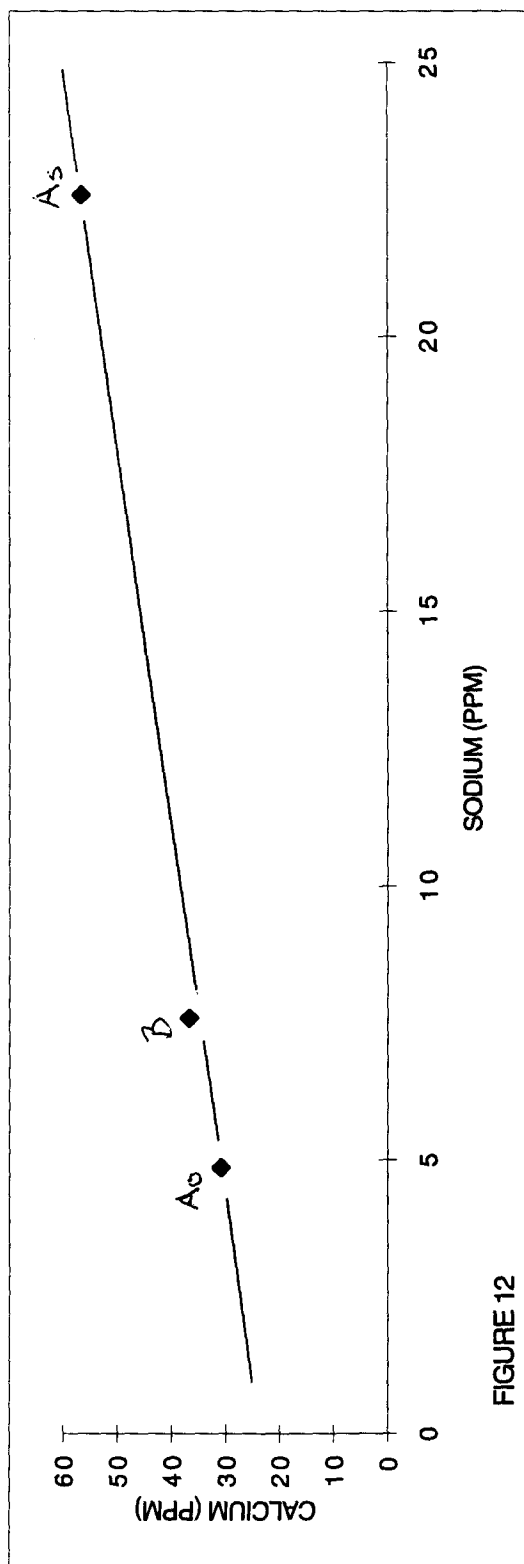


FIGURE 12

Figure 12: Data showing concentrations of calcium and sodium above and below the confluence of the Scioto and Olentangy Rivers. A0 is Olentangy River concentrations above the confluence. As is Scioto River concentrations above the confluence. B is concentrations below the confluence at Shadeville, Ohio.

VI. Summary of Conclusions

The chemical composition of the Olentangy River varies downstream and shows decreasing concentrations of Na, Mg, Zn, Ba, Ca, and Cu. This is due to the increase of discharge of the river with little addition of these elements. Potassium showed a low concentration until just north of the Delaware Reservoir where it begins to increase locally and then decreases as the other elements do. At the French Field House on the OSU campus, a surface runoff pipe caused a local increase in the concentrations of the elements listed above. Once this water had a chance to dilute, the effect disappeared. A mixing diagram was used to help describe chemical composition of the river. Phosphorus, aluminum, iron, strontium, and manganese showed no patterns or trends, so no conclusions can be drawn for these elements. The plots comparing concentrations of calcium, sodium, and magnesium show an unusual trend which could be the basis for another study.

At the confluence of the Scioto and Olentangy Rivers, the concentrations of Na, Mg, Zn, Ba, Ca, and Cu increase due to mixing using data obtained by Hicks, (1994) for the Scioto River.

REFERENCES

1. Eastin, R., and Faure, G., Seasonal Variation of the Solute Content and the Sr /Sr Ratio of the Olentangy and Scioto Rivers at Columbus, Ohio, 1970.
2. Hicks, J. E., Mixing and Anthropogenic Influences on the Chemical Composition of Water Along the Course of the Scioto River, Ohio, 1994.